NON-PUBLIC?: N
ACCESSION #: 9107220232
LICENSEE EVENT REPORT (LER)

FACILITY NAME: Yankee Nuclear Power Station, Rowe, PAGE: 1 OF 11
MA. 01367

DOCKET NUMBER: 05000029

TITLE: Reactor Scram/Turbine Trip and Loss of Offsite Power Due to
Lightning Strike
EVENT DATE: 06/15/91 LER #: 91-002-00 REPORT DATE: 07/16/91

OTHER FACILITIES INVOLVED: DOCKET NO: 05000

OPERATING MODE: 1 POWER LEVEL: 088

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR
SECTION:
50.73(a)(2)(i)
50.73(a)(2)(iv)

LICENSEE CONTACT FOR THIS LER:
NAME: Gregory A. Maret, Technical Director TELEPHONE: (413) 424-5261

COMPONENT FAILURE DESCRIPTION:
CAUSE: X SYSTEM: FC COMPONENT: LAR MANUFACTURER: W120
C EE UJX E356
C EF INVT E209
C FI CBD
REPORTABLE NPRDS: NO
NO
NO
NO

SUPPLEMENTAL REPORT EXPECTED: NO

ABSTRACT:

On June 15, 1991, at 2350 hours, while in Mode 1 at 88% reactor power, a lightning strike resulted in destruction of a lightning arrestor on the No. 3 Station Service Transformer (SST) and flashover of an insulator on the Z-126 115 kV transmission line disconnect switch. As a result, all offsite AC power was lost, an automatic reactor scra
and turbine trip
occurred, and all three EDGs operated as designed. On June 16, 1991, at

0010 hours, an UNUSUAL EVENT (UE) was declared based on the loss of offsite power and a fire emergency (smoldering arrestor). At 0014 hours, one source of offsite power was restored. At 0130 hours, an ALERT was declared at the discretion of the Shift Supervisor. While attempting to normalize the emergency busses, an inadvertent SI actuation signal was initiated at 0155 hours. Following restoration of essential communication systems and plant equipment, the ALERT was de-escalated to an UE at 0450 hours. On June 17, 1991, the plant attained a cold shutdown condition at 0755 hours and the UE was terminated at 0925 hours.

The root cause of this event has been attributed to lightning-induced transients. Immediate corrective actions involved repairing and testing of affected electrical and mechanical equipment and plant instrumentation, and returning normal and emergency communication equipment back to service. A Yankee Investigation Team was assembled to evaluate the event and develop immediate and long-term corrective actions. There was no adverse effect to the public health or safety.

END OF ABSTRACT

INITIAL CONDITIONS

The plant was in Mode 1, at 88% reactor power, with a main coolant EIIS:AB! pressure of 2000 psig, an average temperature of 521 degrees Fahrenheit and a boron concentration of 814 ppm. The plant was operating at a reduced power level to comply with temperature limits on the circulating water system imposed by the National Pollutant Discharge Elimination System (NPDES) Permit. On June 15, 1991, at 2010 hours, the weather alert radio in the Control Room was activated. Sustained winds in excess of 73 MPH were not expected; therefore, no further action was required.

EVENT DESCRIPTION

On June 15, 1991 at approximately 2350 hours, the Yankee Nuclear Power Station experienced a lightning strike which affected both of the independent offsite transmission lines. The lightning strike caused destruction of the Phase A lightning arrestor on the No. 3 Station Service Transformer (SST) EIIS:XFMR! and flashover of an insulator on Phase A of the Z-126-5 115 kV disconnect switch. Table 1 provides a description of the sequence of important events.

As a result of the lightning strike, all offsite AC power was lost for twenty-four (24) minutes. An automatic reactor scram and turbine trip

occurred. All three (3) emergency diesel generators (EDGs) EIIS:DG! operated as designed. EDGs No. 1 and 3 started automatically in response to the deenergization of the two offsite transmission lines. EDG No. 2 was manually started by operators in anticipation of securing the main generator, during realignment of electrical systems in accordance with plant procedures. The control room operators stabilized the plant in a hot standby (Mode 3) condition and verified natural circulation cooling.

On June 16, 1991, at 0010 hours, an UNUSUAL EVENT was declared based on the loss of offsite power and a fire emergency (due to the smoldering lightning arrestor on the No. 3 SST) lasting greater than ten (10) minutes. Notification to the States of Massachusetts and Vermont was delayed due to lightning-induced damage to plant communication systems EIIS:FI!. Alternate means for these notifications to the states and the NRC were established using a dedicated outside telephone line.

At 0014 hours, one source of offsite AC power (Harriman, Z-126, line) was restored. Damage to the lightning arrestor on No. 3 SST and failure of a control circuit relay on OCB Y-177 delayed restoration of the second source of offsite AC power (Cabot, Y-177, line) until repairs could be made.

An ALERT was declared at 0130 hours, at the discretion of the Shift Supervisor, who determined that existing plant conditions warranted a precautionary activation of all emergency response centers and a need for additional

manpower. This determination was based on the continued inoperability of communication systems, the deenergized state of the nonessential uninterruptible power supply (NEUPS) EIIS:UJX!, and the existence of degraded plant equipment (see Table 1).

While attempting to realign the emergency busses to offsite power, an inadvertent safety injection actuation signal (SIAS) EIIS-JE! was initiated at 0155 hours. Main coolant system (MCS) pressure remained above the shutoff head of the safety injection (SI) pumps; therefore, no actual injection was needed and no flow into the MCS from SI occurred.

At approximately 0400 hours, the normal power supply was returned to the No. 1 and 2 vital bus EIIS:BU!. Emergency electrical busses No. 2 and 3 were realigned to an offsite power source and EDGs No. 2 and 3 were secured. Following the restoration of essential communication systems and plant equipment and with the concurrence of the States of Massachusetts and Vermont, the ALERT was de-escalated to an UNUSUAL EVENT

at 0450 hours.

A plant cooldown was initiated at approximately 0700 hours. Plant commercial phone service was restored at 0715 hours, with limited functionality.

On June 17, 1991, the plant attained a cold shutdown (Mode 5) condition at 0755 hours. The UNUSUAL EVENT was terminated at 0925 hours.

A Yankee Investigation Team was assembled to evaluate the event for lessons learned and develop immediate and long-term corrective actions. The Yankee Investigation Team focused on the following areas: plant operations, electrical systems, communication systems and emergency preparedness.

CAUSE OF EVENTS

The root cause of this event has been attributed to lightning impacting equipment on both of the 115 kV transmission lines serving the plant. Subsequent to the lightning strike, the Phase A lightning arrestor EIIS: LAR! on the No. 3 SST failed to reset and was destroyed; an adjacent lightning arrestor sustained consequential damage. As a result, both sources of offsite AC power. were lost and an automatic reactor scram and turbine trip occurred.

The root cause of the failure of various plant communication systems has also been attributed to lightning. Subsequent to the lightning strike, the NEUPS failed to automatically transfer to its backup source; the NEUPS provides power to communication systems equipment at the plant. The loss of NEUPS also caused the failure of other plant instrumentation associated with it. (See Table 1)

The root cause of the sustained loss of the plant commercial phone system (PBX) after the NEUPS was reenergized was a voltage-induced failure of two critical circuit packs EIIS:CBD!. A possible cause of this failure is a lightning-

induced voltage spike that came into the PBX through the telephone lines, independent of the lightning strike affecting the 115 kV transmission lines.

The root cause of the sustained loss of communication systems between the plant and Emergency Operations Facility (EOF) EIIS:NC! has been attributed to the following:

- Failure of plant PBX causing a loss of the lines and a reduction in calling capability over local lines. The loss of tie lines continued after the PBX was restored due to lightning-induced New England Telephone (NET) circuit equipment failures at both the plant and NET Central Office in Readsboro, Vermont.

- Loss of control of the Mt. Massamet and Bordon Mountain transmitters from the EOF due to lightning activity separate from that experienced locally at the plant.

- Loss of the YNPS Nuclear Alert System, the preferred means for making emergency notifications to the states, due to NET circuit failure and failure of equipment at the plant.

- Loss of two ring-down circuits due to NET circuit failures.

The root cause of the inadvertent SIAS is unknown. Subsequent to this event, extensive bench testing was conducted using spare instrumentation (bistable and actuation relay) to simulate the actual instrument loop operation and determine the cause of the spurious SIAS. The results of the bench testing were inconclusive and did not definitively identify a root cause. It is suspected that a combination of voltage and frequency reduction experienced by Vital Bus No. 1 during coastdown of EDG No. 1, after it was tripped by the operators when attempting to realign Emergency Bus No. 1 to offsite power, resulted in the inadvertent SIAS. Vital Busses No. 1 and 2 had both automatically transferred to their bypass supplies, EDGs No. 1 and 3 respectively, as a result of lightning-induced surges.

CORRECTIVE ACTIONS

A. Electrical Systems

Immediate corrective actions involved testing the No. 3 SST. All lightning arrestors on both No. 2 SST and No. 3 SST were replaced. Also, one of the three surge arrestors on the main transformer was replaced. Subsequent to the performance of acceptable tests, the No. 3 SST was reenergized. The damaged insulator on the Z-126-5 disconnect switch was replaced. Extensive testing of selected plant protective relays, voltage regulators and oil circuit breakers on the two offsite power transmission lines was also

conducted. This testing ensured the adequacy of all transmission

line relay functions.

An evaluation of other electrical equipment and plant instrumentation which could have been affected by the lightning strike was also performed.

Miscellaneous instrumentation (power supplies, amplifiers, recorders, etc.) was also repaired.

B. Communication Systems

Immediate corrective actions involved returning normal and emergency communication equipment back to service.

At 0235 hours, on June 16, 1991, the following communication systems were returned to service when power was restored by manually bypassing the NEUPS: Emergency Notification System, Nuclear Alert System and plant radio paging system (two out of three transmitters operable). The plant commercia
phone system (PBX) was returned to
service with limited capability at 0715 hours, after damaged equipment was replaced.

C. Restart Action Items

The following corrective actions were developed by the Yankee Investigation Team and were implemented prior to transition to Mode 4 in preparation for plant restart:

1. Develop and issue a procedure which provides direction for manual bypass of the NEUPS, so that the NEUPS distribution panel can be fed from available power sources.

2. Train operators on performing the NEUPS manual bypass function.

3. Revise procedure OP-2501, "Restoration of Normal AC Power After a Total Loss of AC," to:

a. Alert operators to check the status of the Vital Bus power supply prior to realigning the Emergency Diesel Generator (EDG) and the Emergency Bus.

b. Address the realigning of the EDGs and the Emergency Bus when the EDGs are not backfeeding the associated 480V station service bus.

c. Provide guidance on how to backfeed a deenergized 480V station service bus when only one outside (offsite) line is available.

4. Perform a visual inspection of all solid state equipment that may have been susceptible to lightning strikes and document findings.

5. Include alternate staff augmentation call-in capability in Emergency Plan Implementing Procedures (EPIPs), which provides appropriate contingency actions to address degradation of plant communications.

6. Revise EPIPs to include log-in time on Emergency Response Facility (ERF) personnel log-in forms.

7. Resolve inadvertent safety injection actuation by identifying plausible actuation cause and implementing actions to avoid recurrence.

8. Revise EPIPs to include identification of backup meteorological data for inclusion in notification to the state of Vermont.

9. Provide guidance on all capabilities of each telephone type at all ERFs.

10. Distribute access control keys to shift operations personnel to assure timely controlled access for equipment operation. Establish appropriate controls over these keys and their turnover.

D. Follow-up Action Items

The following long-term corrective actions were developed by the Yankee Investigation Team:

1. Review lightning protection capability of the Cabot (Y-177) and Harriman (Z-126) transmission lines, including the switchyard. Specifically address the absence of a ground wire (static wire, shield wire) on these lines. Provide recommendations of specific enhancements in order of priority.

2. Review lightning protection capability of the station considering ANSI/NFPA-78 and Report NSAC-41. Provide specific

recommendations in order of priority.

3. Perform a station ground resistance test and compare the results with those of a previously-conducted test. Make recommendations for improvement as appropriate.

4. Review all solid-state equipment (including communications equipment) to determine if surge protection capability can be enhanced. Provide specific enhancements and priorities.

5. Determine if the station 115 kV protective relaying and its coordination with Cabot and Harriman stations is adequate or in need of improvement. Provide specific improvements in order of priority.

6. Evaluate parameters requiring verification in procedure OP-3051, "Safety Injection Termination Following Spurious Initiation," and revise procedure as appropriate.

7. Evaluate Emergency Operating Procedures (EOPs) ES-0.1, REACTOR SCRAM RESPONSE, and ES-1.1, SI TERMINATION, to determine the need for adding a check of the status of the Vital Bus power supply prior to realigning the Emergency Diesel Generators (EDGs) and Emergency Busses.

8. Evaluate EOP ES-1.1, SI TERMINATION, to determine the need to direct the operator to realign the Safety Injection System for automatic initiation.

9. Provide improved guidance and training on the use of communications equipment available to emergency response personnel.

10. Evaluate coordination between shift staffing and assigned duties during emergency conditions.

11. Evaluate enhanced diversification of power supplies for emergency assessment equipment.

12. Assemble and stage a telephone equipment repair kit.

SAFETY ASSESSMENT

As a result of lightning, both sources of offsite AC power were lost, and

an automatic reactor scram and turbine trip occurred. The exact sequence of relay action leading to the reactor scram is not known, due to the deenergization of the sequence of events recorder during the event. Following the loss of power to the 40V emergency busses, all three EDGs operated as designed. Power continuity to two main coolant pumps was maintained despite the loss of all offsite power during coastdown of the main turbine-generator, as designed. Control room operators stabilized the plant in a hot standby (Mode 3) condition and verified natural circulation cooling.

As a consequence of lightning, both of the vital busses were briefly deenergized by blown surge protection fuses in their normal DC input supplies. Upon deenergization, the vital bus inverters EIIS:INVT! automatically transferred to their individual backup sources (EDGS No. 1 and 3) and were reenergized by the associated EDG.

Approximately two hours into the event, control room operators attempted to restore normal AC power to Emergency Bus No. 1 from which the No. 1 Vital Bus was energized. In this evolution, EDG No. 1 was secured. A

SIAS occurred after securing the EDG. The operators immediately restarted the EDG to restore power to the No. 1 Vital Bus. The SIAS was verified to be inadvertent.

Subsequent to the SIAS, all high pressure and low pressure safety injection pumps started as designed. Due to the pressure in the main coolant system, water injection did not occur.

At no time during this event was the plant in an unanalyzed condition or in a condition that was outside the design basis of the plant. All Engineered Safety Feature systems and equipment operated as designed. Therefore, the health and safety of the public were not adversely affected as a result of this event.

SIMILAR EVENTS

Similar events at the YNPS involving lightning disturbances resulting in a plant trip have been previously reported in LER 88-08, Rev. No. 1, LER 86-04, LER 83-22, LER 82-19 and LER 80-21.

TABLE 1

SEQUENCE OF EVENTS

6-15-91 2350 Lightning strike

Loss of both offsite AC power sources:

- Harriman (Z-126) transmission line
- Cabot (Y-177) transmission line

Automatic transfer of Vital Busses No. 1 and 2 to their backup sources

Automatic reactor scram and turbine trip

Loss of nonessential uninterruptible power supply (NEUPS) and instrumentation associated with it:

- Safety parameter display system (SPDS)
- Sequence of events recorder (SER)
- Steam generator (SG) process recorders
- Radiation monitoring instrument panels
- Loss of emergency feedwater flow indication (all four loops)

Loss of miscellaneous instrumentation (power supplies, amplifiers, recorders etc.)

Loss of selected communication systems:

- Emergency Notification System (ENS)
- Nuclear Alert System (NAS)
- Plant radio paging system
- Plant commercial phone system (PBX)

Loss of selected security system equipment:

- Security Event Report 91-S01 will provide a description of effects of lightning strike on the YNPS physical security system.

Two emergency diesel generators (EDGs) automatically started - one EDG manually started

Rupture discs blown on LP turbine (three out of four)

2355 Initiated procedure OP-3251, "Loss of AC Supply"

Report of smoke from No. 3 Station Service Transformer (SST) surge arrestor

Fire brigade activated

6-16-91 0010 UNUSUAL EVENT declared

0014 Offsite AC power partially restored - Harriman (Z-126) transmission line

Steam-driven emergency boiler feed pump operating/core decay heat removal occurring through emergency atmospheric steam dump valves

Loss of normal level, pressure and feed indication on No. 2 and No. 4 SG (Channels 2 & 4)

Main coolant system pressure stable at 2000 psig

0030 Fire emergency terminated, fire brigade secured and fire watch established

0035 Initiated procedure OP-2501, "Restoration of Normal AC Power After a Total Loss of AC"

0047 Commonwealth of Massachusetts notified of UE

0050 State of Vermont notified of UE

0052 NRC notified of UE

0130 ALERT declared

0141 Commonwealth of Massachusetts notified of ALERT

0145 State of Vermont notified of ALERT

0155 Inadvertent safety injection actuation signal (SIAS) while normalizing emergency busses using OP-2501

Initiated procedure OP-3051, "Safety Injection Termination Following Spurious Initiation"

0215 NRC notified of ALERT

0235 NEUPS restored

0240 Normal communication lines with NRC (ENS Red Phone) and States (NAS Orange Phone) operational in control room

Plant radio paging system operational

0410 Restored normal power supply to No. 2 vital bus

Secured No. 3 EDG

0413 Restored normal power supply to No. 1 vital bus

0415 Secured No. 2 EDG

0450 Returned 480V Station Service Bus 6-3 to service - power being supplied by No. 1 EDG

De-escalate to UNUSUAL EVENT
(State of Vermont notified and concurred at 0422 hours. Commonwealth of Massachusetts notified at 0422 hours and concurred at 0450 hours.)

0453 Restored power to meteorological monitoring system

0455 NRC notified of de-escalation to UNUSUAL EVENT via ENS Red Phone

0555 SG Channels 2 & 4 returned to service

0625 Preparing for plant cooldown - main coolant system (MCS) stable at 2000 psig and 494 degrees F

Pressurizer level at 124 inches

SG feed with main feedwater system

Steam released through emergency atmospheric steam dump valves

Preparing to borate MCS and restart main coolant

pumps

0715 Operability of plant commercial phone system restored
with limited functionality

6-17-91 0755 Plant attained cold shutdown (Mode 5) condition

0925 Termination of UNUSUAL EVENT

ATTACHMENT 1 TO 9107220232 PAGE 1 OF 1

YANKEE ATOMIC ELECTRIC COMPANY Telephone (413) 424-5261

HC87 Box 160, Rowe, Massachusetts 01367

July 16, 1991
BYR 91-089

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555

Subject: Licensee Event Report No. 50-29/91-002

Reactor Scram/Turbine Trip and Loss of Offsite
Power Due to Lightning Strike

Dear Sir:

In accordance with 10 CFR 50.73 (a) (2) (i) and 10 CFR 50.73 (a) (2) (iv), the attached Licensee Event Report is hereby submitted. A one day extension was granted by the USNRC Senior Resident Inspector.

Very truly yours,

Normand N. St. Laurent
Plant Superintendent

DJK/pkc
ENCLOSURE

cc: 3! NSARC Chairman (YAEC)
1! Institute of Nuclear Power Operations (INPO)
1! USNRC, Region I
1! Resident Inspector

*** END OF DOCUMENT ***